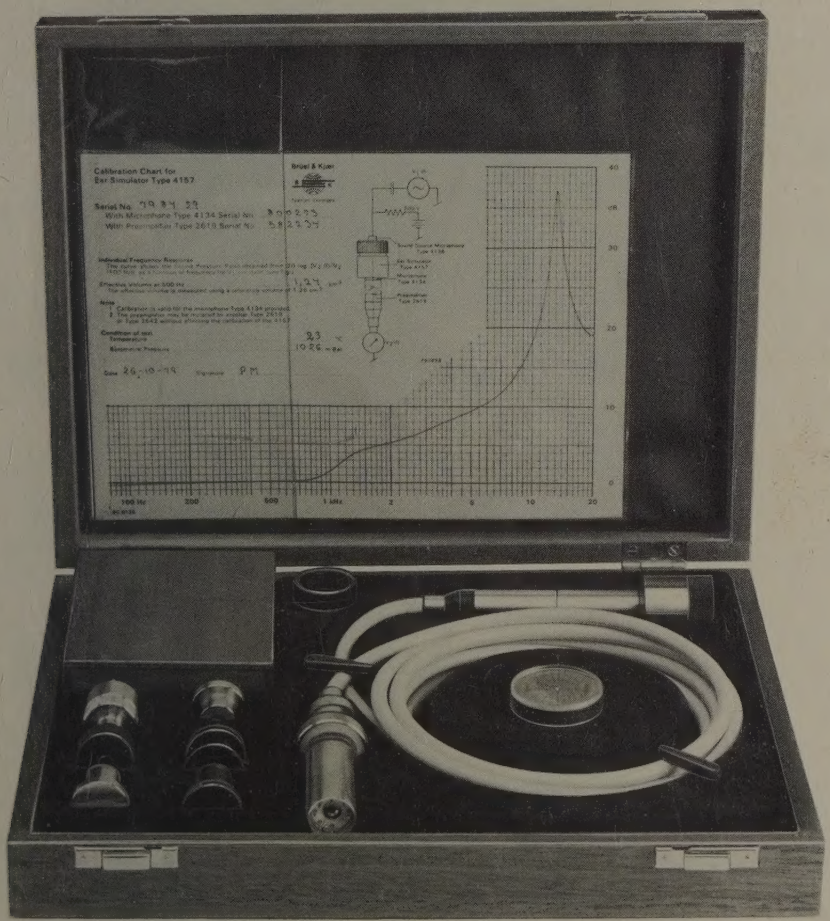
4157

Instruction Manual

Ear Simulator Type 4157



The Ear simulator Type 4157 is designed to provide stable, well-defined acoustic conditions for testing earphones, and hearing aids connected to the ear by insert earphones, ear inserts or personal ear moulds. It closely reproduces the physical and acoustical parameters of the actual human ear, providing the earphone under test with a similar acoustical impedance, and complies with ANSI and IEC standards.

Brüel & Kjær

EAR SIMULATOR
TYPE 4157

Applicable to instruments

from serial no. 1054900

Revision March 1985

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4.1. DISMANTLING AND REASSEMBLING THE EAR SIMULATOR 14

Ear Simulator

FEATURES:

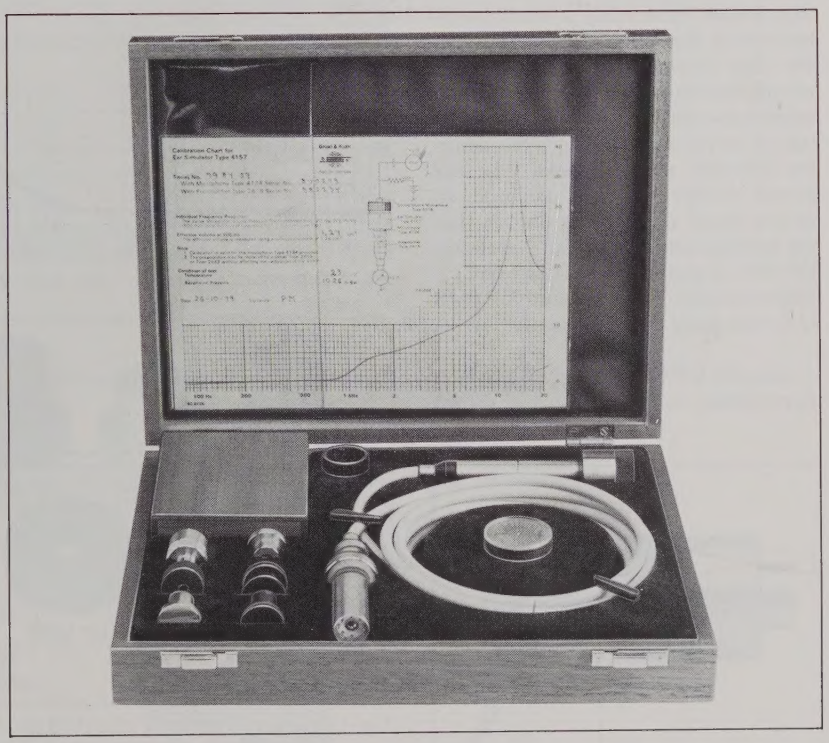
- Comforms to IEC 711 and ANSI S3.25/1979 (ASA 39/1979) Standards
- Simple and straightforward calibration procedure
- Well defined measuring conditions
- Individually calibrated
- Wide range of accessories included

USES:

- Frequency response and sensitivity measurements on hearing aids using insert earphones
- Servicing of hearing aids
- Production testing of earphones

Description

The Ear Simulator Type 4157 is primarily intended for measurements on hearing aids using air conduction earphones coupled to the ear by ear inserts such as tubes or personal ear moulds. It has therefore been designed to fulfil the requirements of IEC 711 and ANSI S3.25/1979 (ASA 39/1979) standards for an ear simulator for measurements using insert earphones. The Ear Simulator Type 4157 closely reproduces the physical parameters of the human ear, presenting the insert earphone under test with an impedance approximating that of the real human ear.



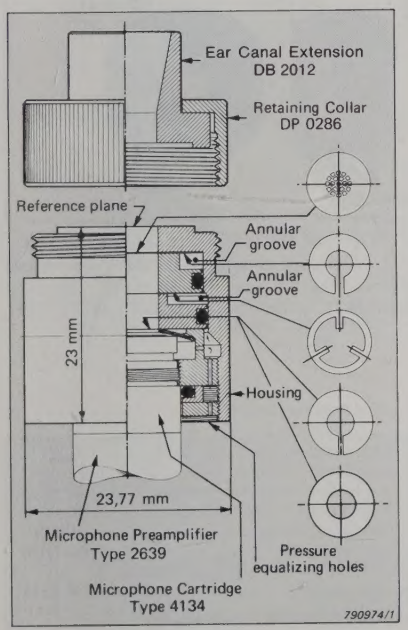


Fig. 1. Sectional drawing of the Ear Simulator showing external ear simulator DB 2012 and clamping collar

The Ear Simulator consists of a main housing into which are assembled a number of rings whose shapes form annular air volumes connected to the main volume of the housing by air passages. The main ear canal volume is of a similar shape and volume to that of the actual human ear and provides a similar acoustic impedance to the insert earphone being tested. The combined Microphone Type 4134 and Preamplifier Type 2639, supplied with the set, are screwed directly into the housing of the Ear Simulator, terminating the main ear canal volume.

To ensure that measurements are reproducible and can be compared with each other, a reference measurement plane is defined, see Fig. 1. This is perpendicular to the ear canal axis at the normal position of the tip of the ear mould.

The Type 4157 is delivered in a mahogany case with an individual calibration chart giving all parameters for its correct use (see Fig. 2).

Accessories

A number of adaptors, which can be mounted flush with the reference plane, are delivered with the Ear Simulator, both for mounting a wide range of earphones in current use and for special measurements on the Ear Simulator itself. See Fig. 4.

The ear mould simulator DB 2015 is for testing insert earphones. The external ear simulator DB 2012 simulates the whole of the external ear channel, and may be used to calibrate the measuring chain with the Pistonphone Type 4220. When used for this purpose the calibration level produced by the pistonphone is 0,7 dB lower than when calibrating a microphone because of the much larger volume of the Ear Simulator cavity. The ear mould simulator DP 0370 is for testing behind-the-ear hearing aids. For testing all-in-the-ear hearing aids, adaptor DP 0530 may be used. The ear mould holder DS 0540 is used to mount small ear moulds and in-the-ear hearing aids on the Ear Simulator. DS 0541 is similar to DS 0540 but for larger moulds. The tube stud DP 0368 is for modular hearing aids.

Adaptor DP 0276 accepts a 1/4 inch microphone to be used as a sound source for testing the Ear Simulator, and UC 0124 is a special tool for removing the microphone. The adaptors are secured by an internally threaded collar DP 0286.

For customers already possessing the Preamplifier Type 2619, 2642 or 2639, the Ear Simulator can be delivered without the Preamplifier Type 2639.

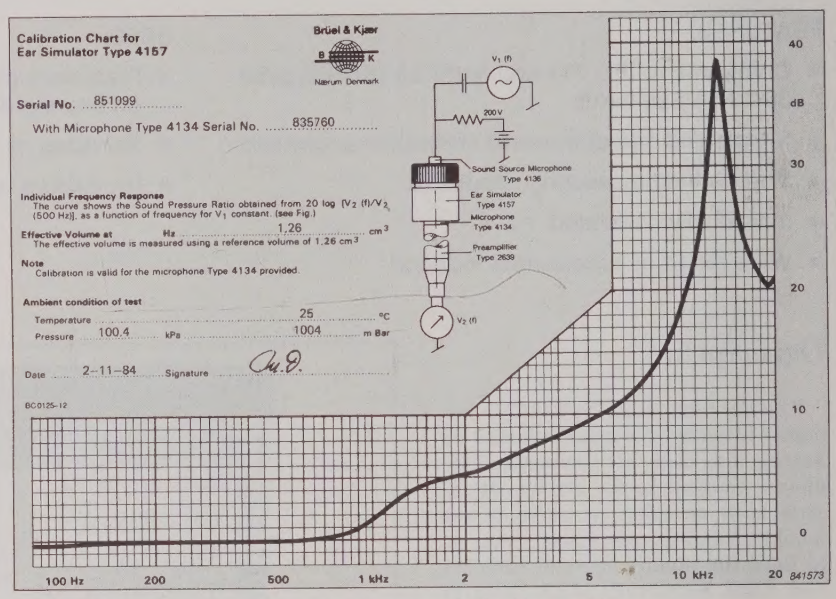


Fig. 2. Individual calibration chart delivered with the Type 4157

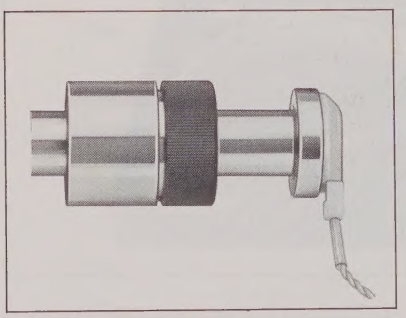


Fig. 3. Mounting an insert earphone using ear mould simulator DB 2015

Fig. 4. Accessories delivered with the Type 4157. Top row, left to right: ear mould simulator DB 2015, external ear simulator DB 2012, ear mould simulator DP 0370, ear mould holder DS 0540, ear mould holder DS 0541, Bottom row, left to right: tube stud DP 0368, 1/4-inch microphone adaptor DP 0276, microphone removal tool UC 0124, ear mould holder DP 0530

Specifications 4157

DIMENSIONS OF HOUSING:
Height: 23 mm
Maximum diameter: 23,77 mm

EFFECTIVE VOLUME:
1,26 ± 0,03 cm^3 at 500 Hz

CALIBRATION TEMPERATURE RANGE:
23 ± 3°C

CALIBRATION AMBIENT PRESSURE:
101,3 kPa ± 3 kPa (1013 ± 30 mbar)

RESONANT FREQUENCY:
14 ± 1 kHz

ACCESSORIES INCLUDED:

Calibration Chart	
Condenser Microphone	Type 4134
Microphone Preamplifier	Type 2639
External Ear Simulator	DB 2012
Ear Mould Simulator	DB 2015
Tube Stud	DP 0368
Ear Mould Simulator	DP 0370
Ear Mould Holder	DS 0540
Ear Mould Holder	DS 0541
1/4 inch Microphone Adaptor	DP 0276
Microphone Removal Tool	UC 0124
Retaining Collar	DP 0286
Dust Protector	DS 0535
Adaptor for all-in-the ear hearing aids	DP 0530

ACCESSORIES AVAILABLE:

Adaptor for kEMAR® manikin	WA 0235

2. OPERATION

2.1. PRELIMINARY

A sectional view of the Ear Stimulator Type 4157 is shown in Fig. 2.1, showing the internal construction and the separating rings in detail.

The Ear Simulator is delivered fully assembled and calibrated, and ready for use. It is only necessary to mount the correct adaptor and connect the earphone or hearing aid on which the measurements are to be made.

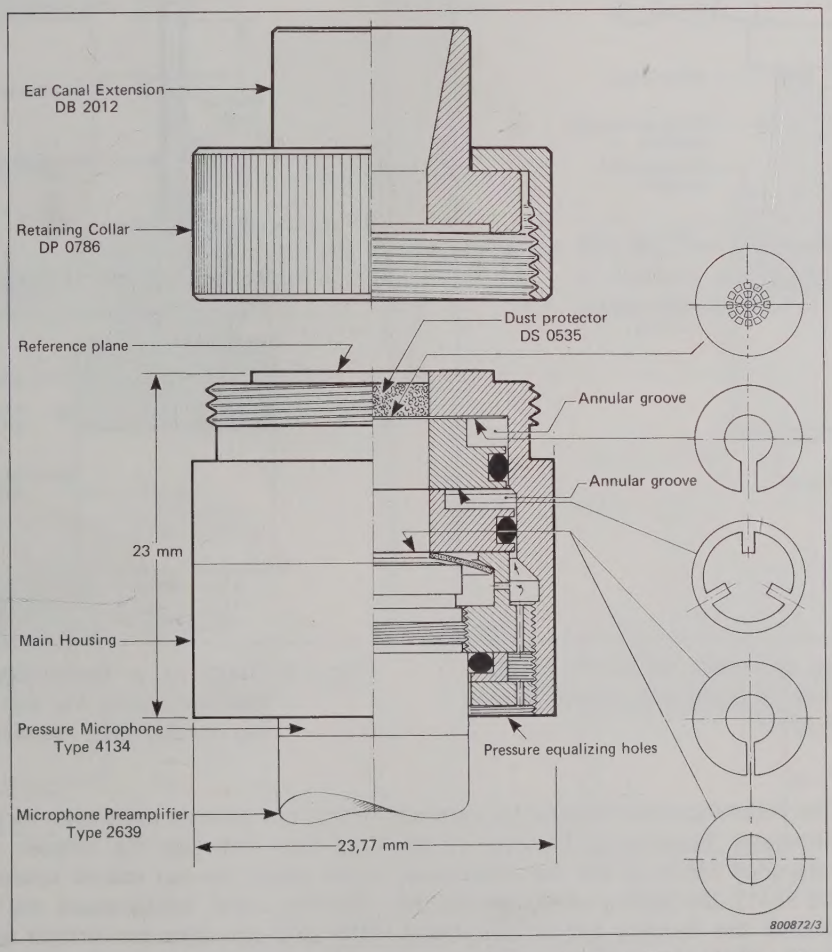


Fig. 2.1. Sectional view of the Ear Simulator Type 4157 including the retaining collar and ear canal extension

2.2. COUPLING THE EARPHONE TO THE EAR SIMULATOR

The wide range of adaptors supplied with the Ear Simulator enables easy coupling of all types of insert earphones and hearing aids. The earphone, ear plug or ear mould simulator, must always be mounted level with the reference plane of the Ear Simulator to obtain the greatest repeatability of measurements. The ear plug simulator (DP 0370), the ear mould simulator (DB 2015) and the tube stud (DP 0368) are correctly located automatically by the retaining collar. When coupling in-the-ear earphones, ear inserts or personal ear moulds using the ear mould holders (DS 0540, DS 0541 or DP 0530), care should be taken to ensure that their openings are mounted level with the reference plane. Figs. 2.2 to 2.7 show the various methods of coupling different types of hearing aids and earphones to the Ear Simulator using the adaptors supplied.

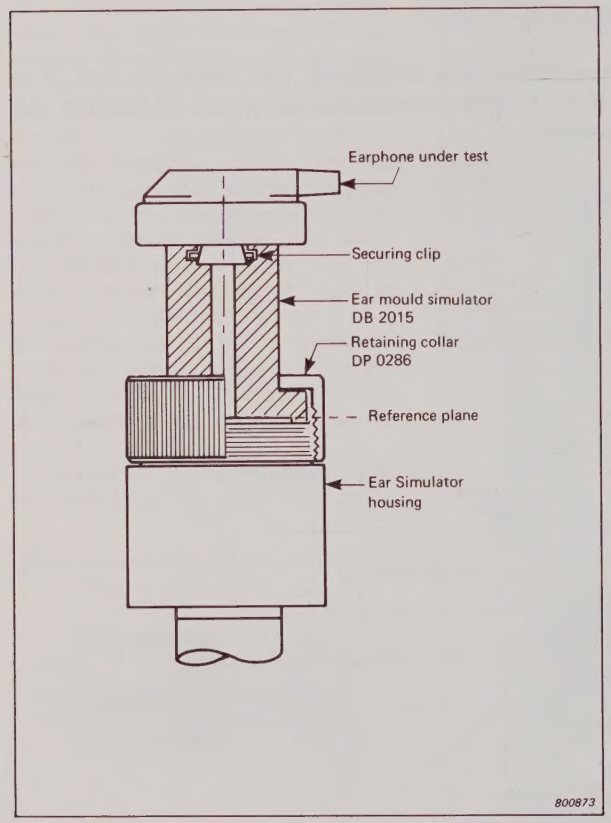


Fig. 2.2. Coupling an insert earphone to the Ear Simulator using ear mould simulator DB 2015

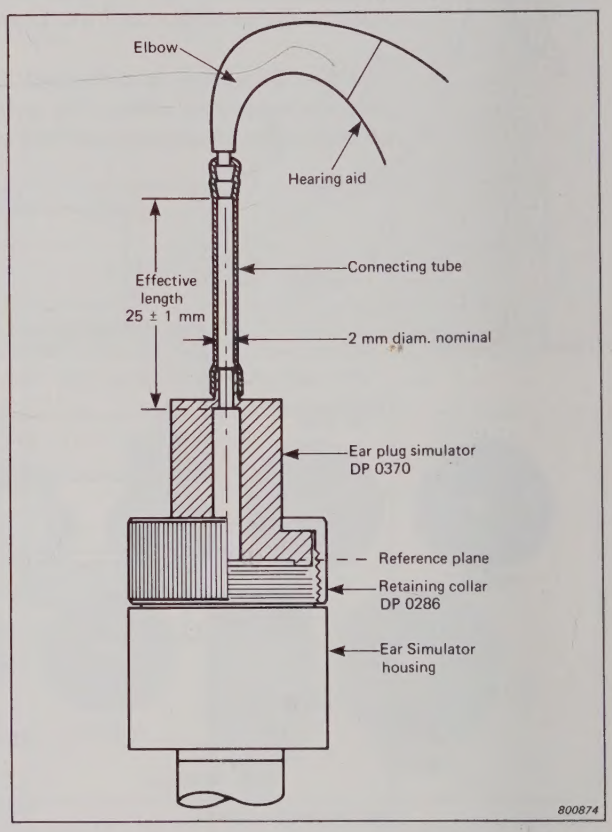


Fig. 2.3. Coupling a behind-the-ear type of hearing aid to the Ear Simulator using the ear plug simulator DP 0370

The retaining collar should be screwed firmly, but without excessive torque, onto the Ear Simulator housing to provide an air tight seal between the chosen adaptor and the reference plane of the Ear Simulator. When using the ear mould holders, (DS 0540 and DS 0541), the action of tightening the retaining collar compresses the holder so that it grasps the hearing aid or ear insert firmly and provides an airtight seal. The two ear mould holders supplied have different internal diameters to deal with the majority of ear moulds and inserts of different sizes in common use.

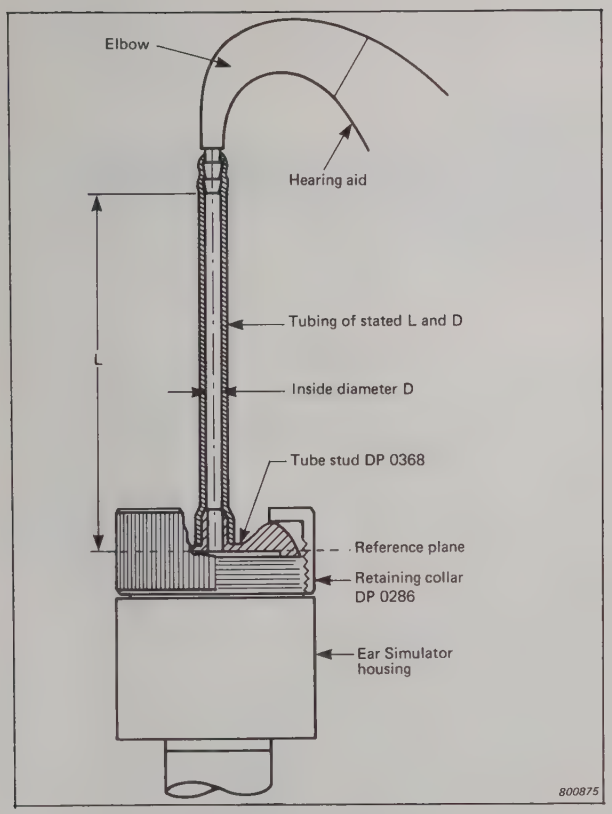


Fig. 2.4. Coupling a behind-the-ear type of hearing aid to the Ear Simulator by tubing using tube stud DP 0368

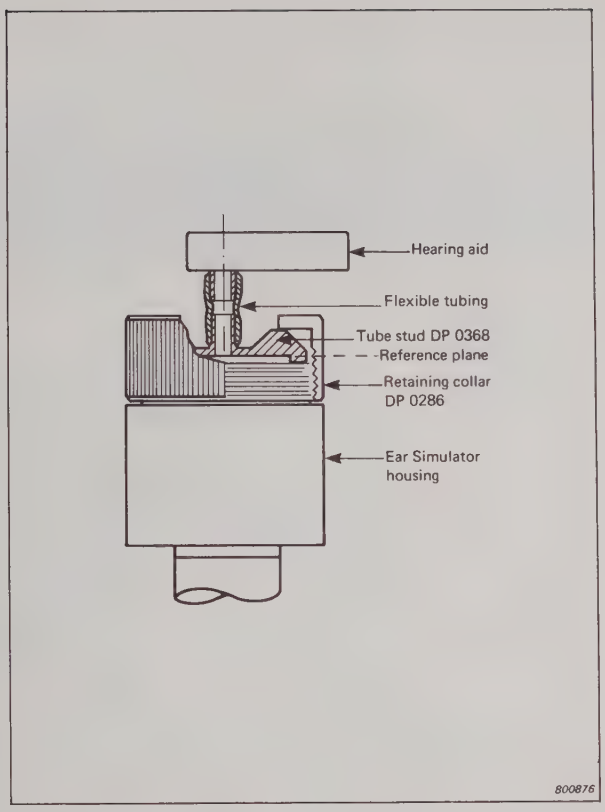


Fig. 2.5. Coupling an in-the-ear modular type of hearing aid to the Ear Simulator using tube stud DP 0368

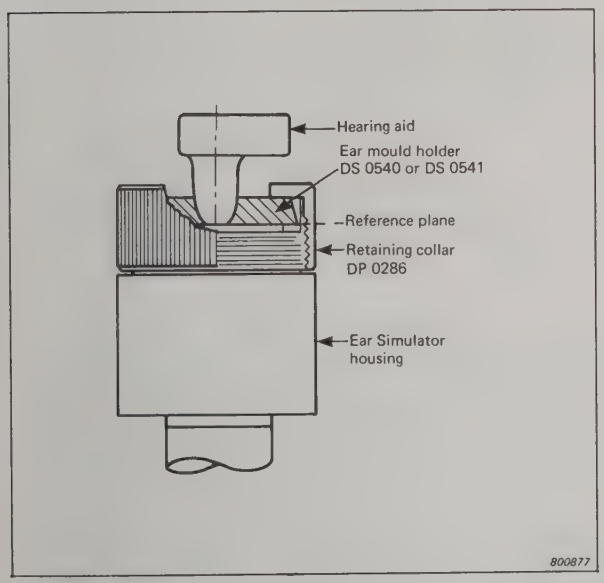


Fig. 2.6. Coupling a custom made in-the-ear type of hearing aid to the Ear Simulator using ear mould holder DS 0540 or DS 0541

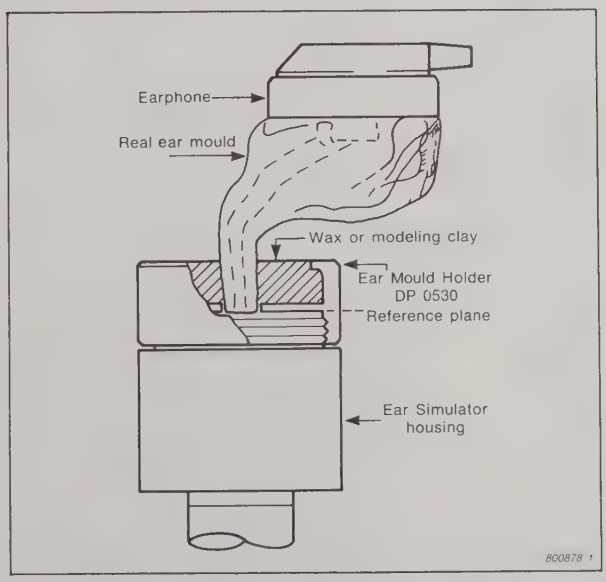


Fig. 2.7. Coupling insert earphone plus real ear mould to the Ear Simulator using ear mould holder adaptor DP 0530 with wax or modelling clay for an air-tight seal and support

The real ear mould holder, adaptor (DP 0530), has been designed to be used with wax or modelling clay in order to form a support and make an airtight seal between the mould and the Ear Simulator. See Fig. 2.7.

Note: The Ear Simulator is delivered with a number of polyurethane foam dust protectors (DS 0535), which fit into the Ear Simulator housing at the end remote from the microphone, against the upper perforated disc, as shown in Fig. 2.1. It is recommended that one of these dust protectors is always in place to protect against the gradual ingression of dust. Further details can be found in section 3.6.

2.3. CALIBRATION

Calibration of the measuring chain is most easily carried out using the Pistonphone Type 4220 or the Sound Level Calibrator Type 4230 which supply stable, accurate tones at 250 Hz or 1 kHz respectively. These can be fitted directly to the Ear Simulator after mounting the ear canal adaptors DB 2012, DB 2015 or DP 370 as shown in Fig. 2.8. Fit the Pistonphone or Sound Level Calibrator with a half inch microphone adaptor (DB 0311), and press the Ear Simulator into the cavity of the Pistonphone or Sound Level Calibrator, ensuring a good airtight fit. See Fig. 2.9.

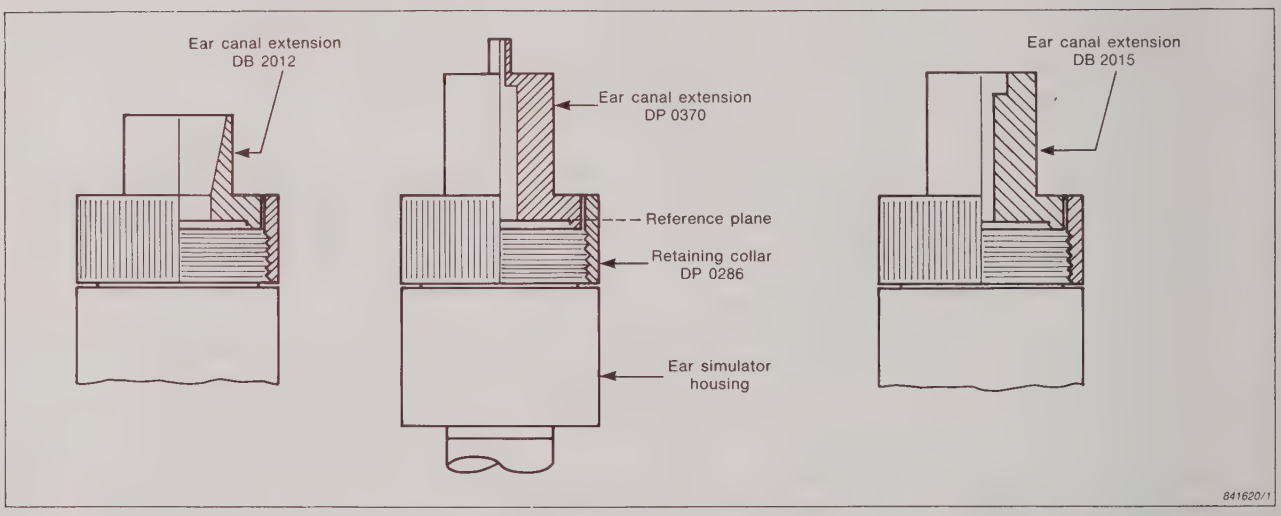


Fig. 2.8. The adaptors DB 2012, DP 0370 and DB 2015 that can be used for calibrating

The Sound Level Calibrator Type 4230 and the Pistonphone Type 4220 state values for the sound level produced when connected to standard one–inch B & K microphones with a standard protection grid. This arrangement provides for a standard coupler volume, and hence a standard sound level output. The Ear Simulator has an effective volume different from that of the standard microphones however, and the sound level produced will therefore be different to the values stated on their calibration charts. (See Instruction Manual for the Sound Level Calibrator Type 4230 or Pistophone Type 4220 for a more detailed explanation). For this reason the exact values of calibrated sound for the Pistonphone and the Sound Level Calibrator when used to calibrate the Ear Simulator with its adaptors have been given in Table 2.1.

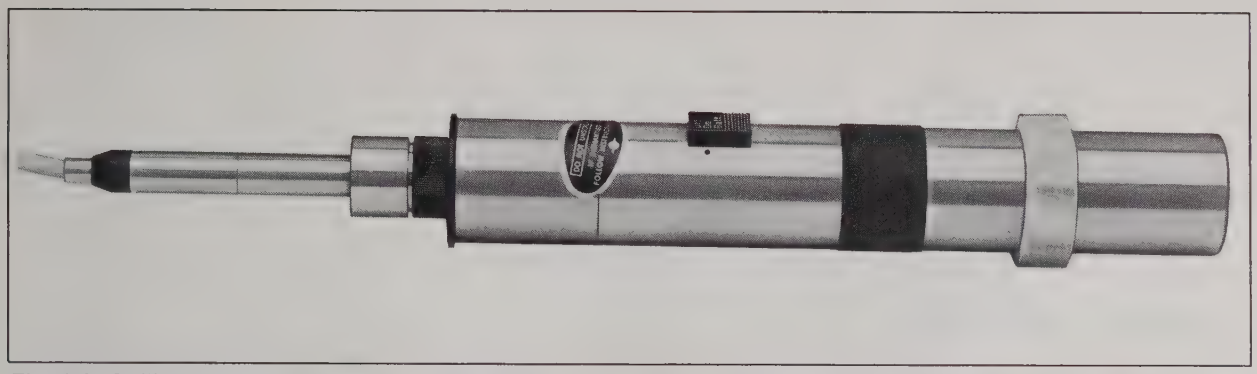


Fig. 2.9. Calibration using the Pistonphone. The sound level produced is dependent upon the type of ear mould adaptor used. See Table 2.1

Calibrator	Adaptor		
	DB 2012	DB 2015	DP 0370
4220	123,3 dB	124,2 dB	124,6 dB
4230	95,2 dB	98,7 dB	—

T00605GB1

Table 2.1 The calibrated sound output levels from the Pistonphone Type 4220 and Sound Level Calibrator Type 4230, when calibrating the Ear Simulator with its respective adaptors. These values replace those stated on the calibration charts of the Pistonphone and Sound Level Calibrator

Note: The Microphone Type 4134 is an integral part of the Ear Simulator and should not be removed for calibration.

3. CHARACTERISTICS

3.1. FREQUENCY RESPONSE

The frequency response of each Ear Simulator is measured at the factory and a calibration chart is supplied with it. (See Fig. 2., chapter 1). On the calibration chart the effective volume at 500 Hz, as well as the frequency response relative to this value, is given. The tolerances of the magnitude of the acoustic transfer impedance, as specified by ANSI and IEC standards for an occluded ear simulator, together with a frequency response of a typical Ear Simulator are shown in Fig. 3.1. The reference value at 500 Hz is 35,9 MPa.s.m^{-3}, corresponding to the effective volume of the ear simulator of 1,26 cm^{-2}.

Further discussion of frequency response measurement on the Ear Simulator using a sender microphone and the special adaptor (DP 0276) can be found in section 3.4.

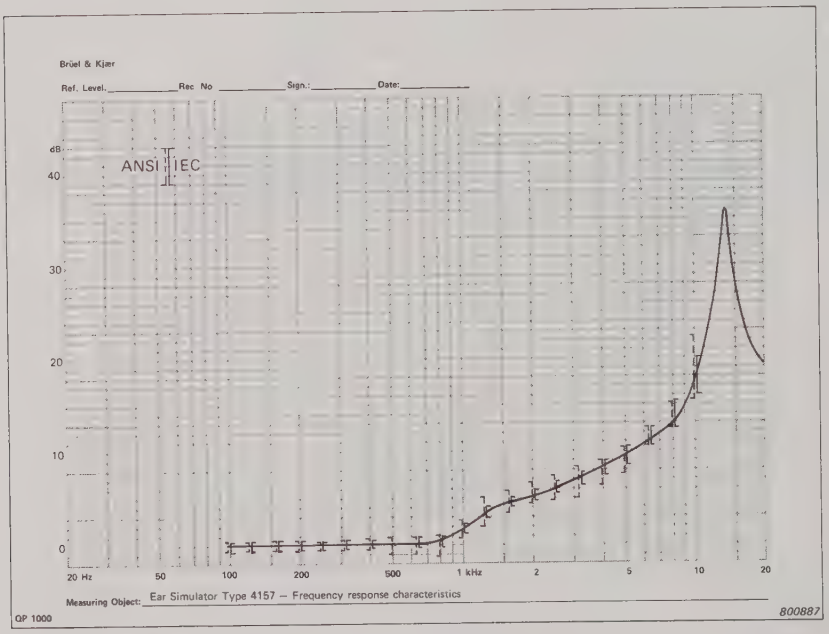


Fig. 3.1. Frequency response of a typical Type 4157 Ear Simulator with the tolerances allowed by ANSI and IEC superimposed

3.2. PHASE CHARACTERISTICS

In addition to stating tolerance limits for the amplitude reponse, the ANSI Standard also gives limits for the phase response of the Ear Simulator. There are no similar limits stated by the IEC 711 standard. Fig. 3.2 shows a typical phase response for the Type 4157 Ear Simulator with the ANSI tolerance superimposed.

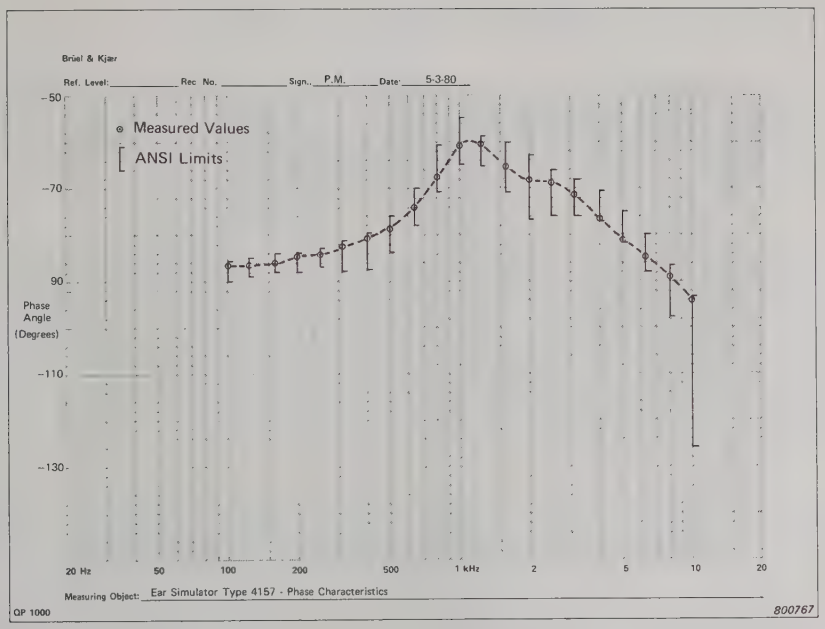


Fig. 3.2. Phase characteristics of a typical Type 4157 Ear Simulator compared with the tolerances allowed by ANSI

3.3. INPUT IMPEDANCE

The input impedance is shown in Fig. 3.3. The value at 500 Hz is used as the reference to express the amplitude in dB. For the example shown this value is 35,6 MPa.s.m^{-3}.

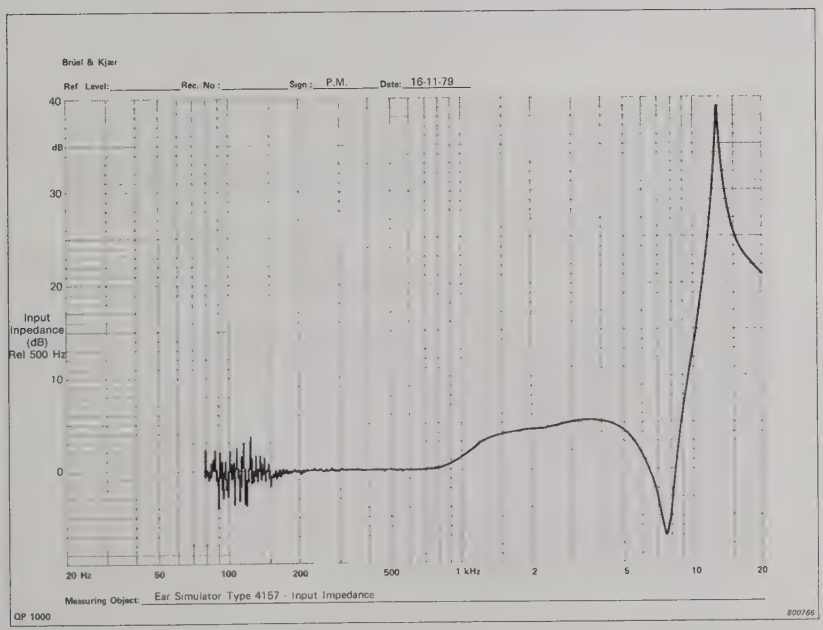


Fig. 3.3. Input Impedance of a typical Type 4157 Ear Simulator

3.4. DETERMINING THE FREQUENCY RESPONSE OF THE EAR SIMULATOR

The Ear Simulator Type 4157 is calibrated at the factory and supplied with all the data necessary for its correct use. However, to enable the user to carry out a frequency response calibration, the Ear Simulator is delivered with a special adaptor (DP 0276) so that a quarter inch Condenser Microphone Type 4136 can be attached to operate as a sender microphone.

Dismantling the Ear Simulator is not recommended unless absolutely essential. If it is dismantled for any reason it should be recalibrated after reassembly to ensure that it remains within tolerances. A measurement system suitable for calibration is shown in Fig. 3.4. The Heterodyne Analyzer Type 2010 supplies a pure sinusoidal signal of constant amplitude to the sender microphone via a special adaptor (WA 0160). The signal from the built-in microphone of the Ear Simulator is analyzed by the Heterodyne Analyzer and the resultant frequency response output plotted with an X-Y Recorder Type 2308.

For accurate measurement of the resonance frequency of the Ear Simulator, which occurs at frequencies above its normal working range (i.e. above 10 kHz), it is necessary to seal the small annular gap between the sender microphone and the adaptor (DP 0276). The sealing compound recommended, "LITHELEN-Hochvakuum-Fett", is a high vaccuum sealing grease which will help to make the gap airtight. The sealing compound should be introduced at the position shown in Fig. 3.5.

Note: The diaphragm of the microphone is delicate and easily damaged. While performing the above operation it should not be touched, nor should the sealing compound be allowed to come into contact with its surface.

For normal calibration checks over the working frequency range of the Ear Simulator (i.e. from 100 Hz to 10 kHz), sealling can normally be omitted. The effect of using and omitting the sealing compound is demonstrated in Fig. 3.6. It can be clearly seen that the frequency response below 10 kHz is not significantly altered and still remains within tolerance and that the resonance frequency is just a little lower.

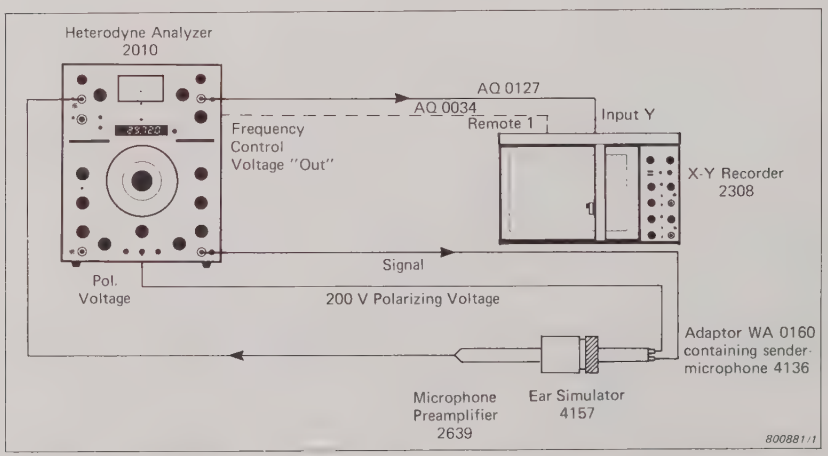


Fig. 3.4. Measurement arrangement for determining the frequency response of the Ear Simulator

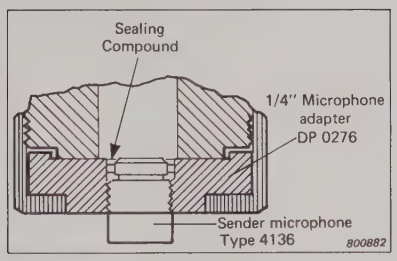


Fig. 3.5. Method of sealing the volume between the quarter inch sender microphone and the microphone adaptor DP 0276 using a special sealing compound

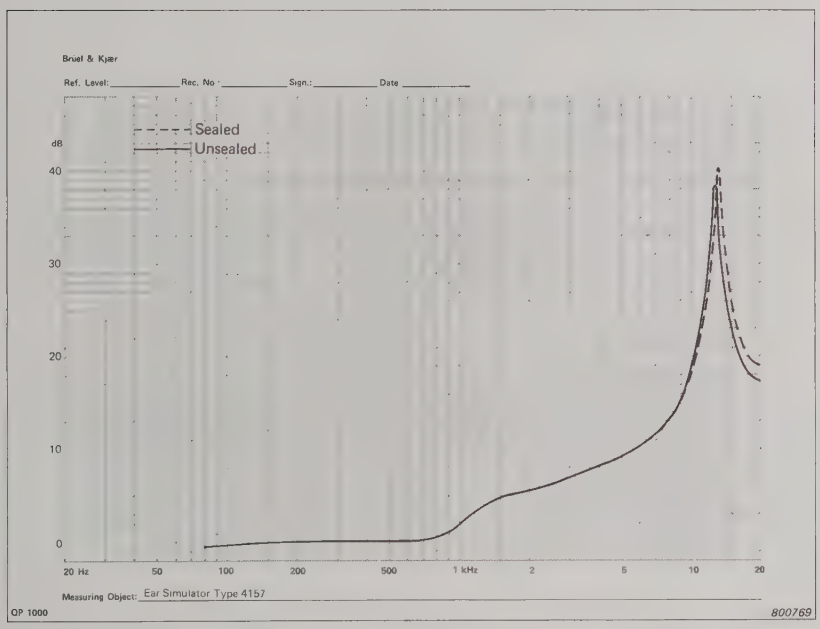


Fig. 3.6. Influence of sealing the Sender microphone on the resonance frequency of the Ear Simulator

3.5. INFLUENCE OF AMBIENT PRESSURE CHANGES

The data and frequency response of the Ear Simulator are stated on the calibration chart supplied, and this calibration has been made at the quoted value of atmospheric pressure, which is close to normal. A large difference from the normal ambient pressure, occuring at high altitudes for example, will result in a slight change of frequency response. However, the tolerances on the frequency response are complied with for ambient pressures down to approximately 800 mbar (80 kPa.), corresponding to an altitude of approximately 2000 m. Frequency response curves for three values of ambient pressure are shown in Fig. 3.7 showing the variability to be expected.

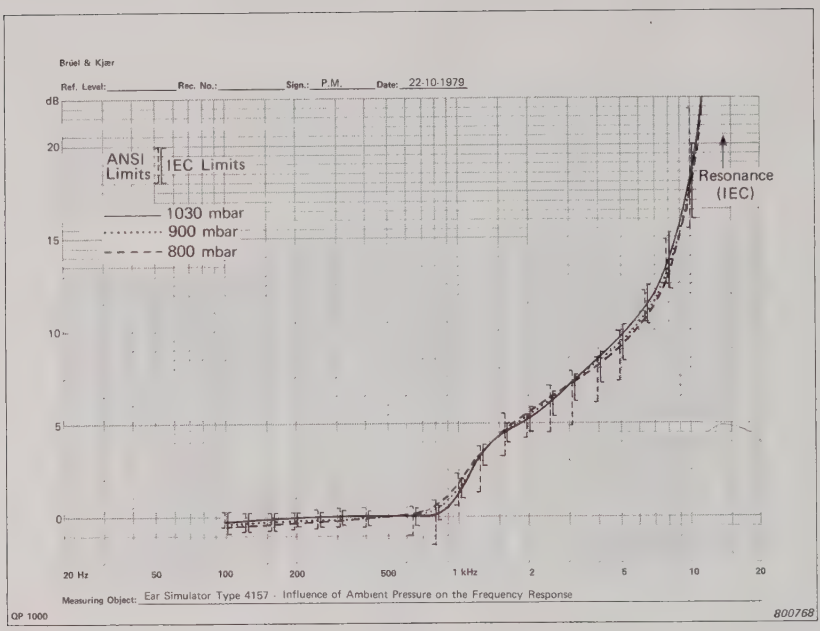


Fig. 3.7. Influence of static pressure on the frequency response of the Ear Simulator Type 4157

3.6. INFLUENCE OF THE DUST PROTECTOR

It is recommended that the dust protector DS 0535 is always kept in place in the Ear Simulator to prevent the ingression of dust which may slightly effect its characteristics in the long term. The dust protector does have a small effect on both the frequency response and the resonant frequency. However, the changes are not significant as they lie within the accepted frequency response tolerance of the ANSI and IEC standards. In Fig. 3.8 the frequency response is shown both with and without the dust protector and

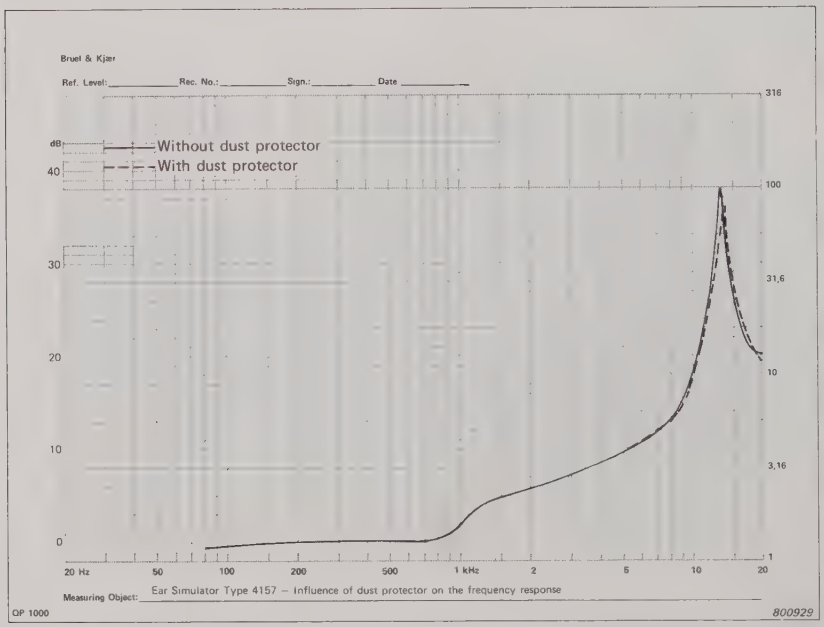


Fig. 3.8. Influence of the dust protector on the frequency response

demonstrates the small difference between them, and in practice this difference lies within the accuracy of measurement.

3.7. REFERENCES

IEC 711–1981 Occluded-ear simulator for the measurement of earphones coupled to the ear by ear inserts.

ANSI S3.25–1979 (ASA 39 - 1979) American National Standard for an Occluded Ear Simulator.

4. SERVICE AND REPAIR

The Ear Simulator Type 4157 is a precision instrument. It has been designed to provide the user with many years reliable operation and under normal use no significant deviation from the stated specifications should occur.

For repair consult the seperate Service Instruction Manual for the instrument or contact your local B & K representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic measuring instrumentation.

4.1 DISMANTLING AND REASSEMBLING THE EAR SIMULATOR

It should not normally be necessary to dismantle the Ear Simulator, and it is not recommended. However, if for any reason it becomes necessary to do so, it can be dismantled using the microphone removal tool UC 0124 as follows:

1. Unscrew the Ear Simulator from the Preamplifier.

2. Insert the two projecting pins of the microphone removal tool UC 0124 into the two corresponding holes in the securing ring DB 2223 and unscrew it from the housing (DB 2215). This releases the O-ring holder and O-ring which can be eased out by a small screwdriver or by tapping the housing gently against the hand. See Fig. 4.1 (a).

3. The microphone holder ring DB 2218 is now accessible and, together with the microphone, can also be screwed out of the housing using the removal tool as before. The microphone can now be screwed out of the holder. No attempt should be made to remove the plastic ring YO 0739 from the holder. The two spacers YO 0742 and OD 0319 can now be taken out. See Fig. 4.1 (b).

   Note: During this operation great care should be taken to ensure that the microphone diaphragm is not touched or contaminated in anyway by oil, dust or grease etc.

4. The other end of tool should now be inserted into the housing as shown in Fig. 4.1 (c) and the screw in the centre of the tool tightened with a screwdriver so that it firmly grips the first coupler ring DB 2217 internally. This coupler ring, together with its O–ring can then be pulled out, enabling the spacer OD 0320 to be removed.

5. Use the same procedure to remove the second coupler ring DB 2216 and the final two spacers OD 0321 and YO 0740. See Fig. 4.1 (d).

6. The reassembly procedure is exactly the reverse of the above.

7. The calibration of the Ear Simulator should now be checked as in section 3.4.

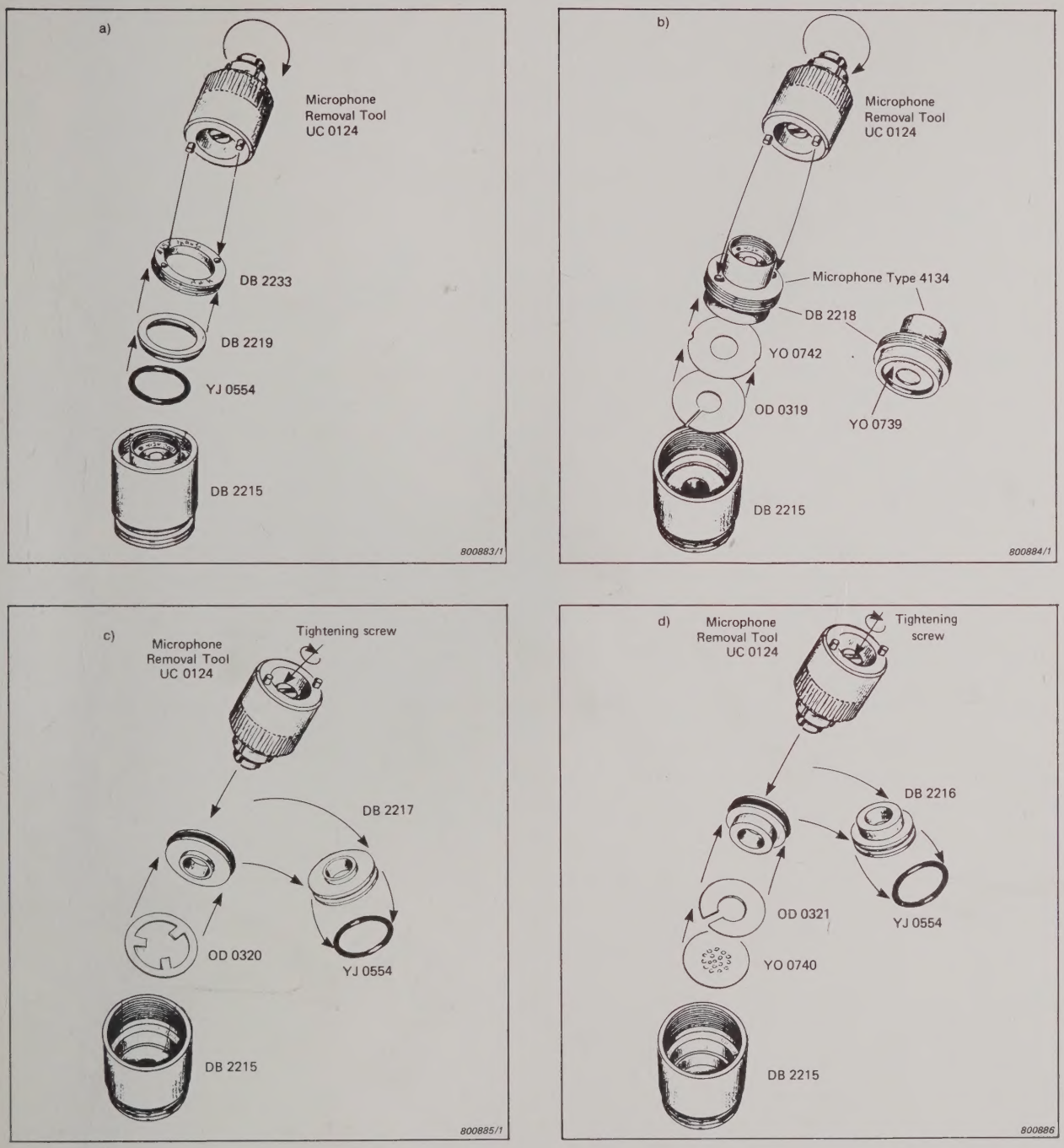
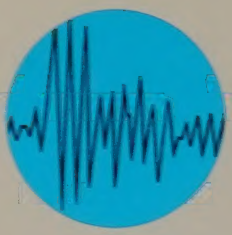
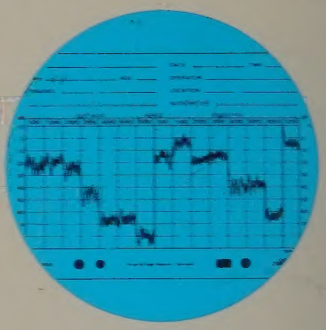
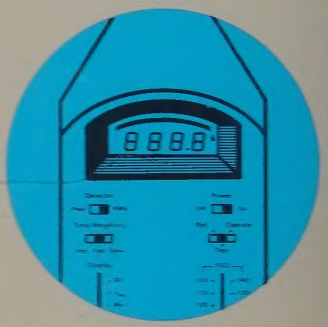
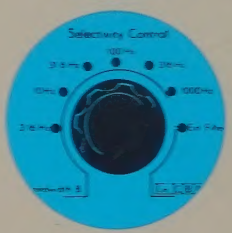


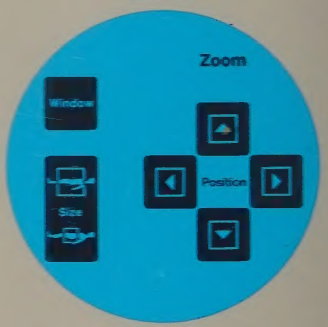
Fig. 4.1. Dismantling procedure and part numbers for the Ear Simulator Type 4157

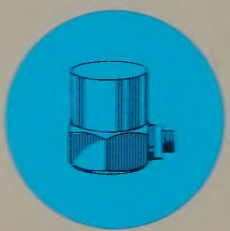


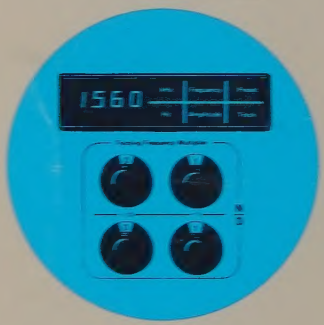


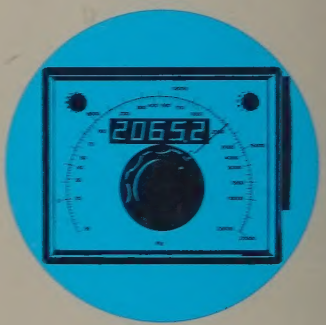


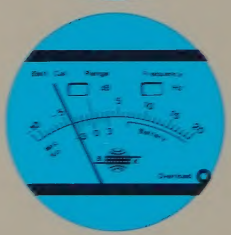


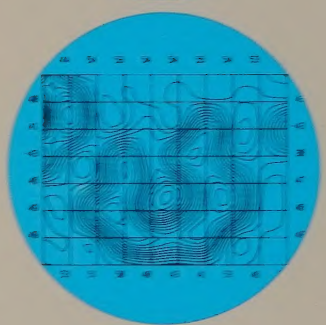


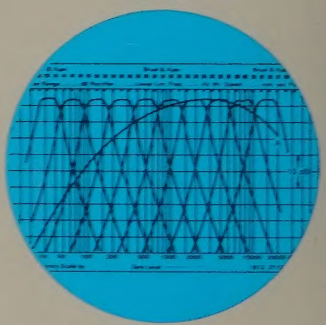












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